Determination of Intestinal Viability by Doppler Ultrasonography in Venous Infarction

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The accuracy of Doppler ultrasound in predicting the viability of ischemic intestine secondary to venous obstruction was assessed. Twenty loops of ischemic intestine were created in dogs by temporarily obstructing venous return from the bowel. Doppler arterial flow signals within the intestine quickly disappeared following venous occlusion. In ten segments, arterial signals promptly returned following release of venous occlusion. Nine of these ten segments were viable at reoperation 24 hours later. In ten segments, no arterial signals could be detected following release of venous occlusion, and only one segment proved to be viable. Doppler ultrasound findings were far more accurate in distinguishing between viable and nonviable intestine than were clinical guides to intestinal viability.

THE DOPPLER ULTRASONOGRAPHIC technique has been proved to be exquisitely sensitive in predicting the viability of intestine ischemic owing to the interruption of arterial flow.[1-3] But, many clinical situations of vascular embarrassment to bowel are produced by venous rather than arterial occlusion. Among these are closed loop obstruction, volvulus, intussception, and internal and external hernias. Because these situations occur more frequently than those which cause arterial ischemia, an experiment was designed to test the usefulness of the Doppler technique in determining intestinal viability in venous occlusion of the intestine.

Method

Five healthy mongrel male dogs (average weight 20 kg) were anesthetized with thiamylal sodium. A midline laparotomy was performed under sterile conditions. Four 12 cm loops of intestine were isolated, and the venous supply to each loop was carefully isolated. The venous return from each loop was temporarily occluded with vascular clamps, and collateral vessels within the bowel were occluded by placing intestinal clamps across the proximal and distal margins of each loop. The arterial supply to each loop was carefully preserved.

Prior to occluding the venous flow and ten minutes after accomplishing it, a 9 MHz sterile Doppler probe was passed over the antimesenteric surface of the bowel wall to determine whether audible arterial flow signals were present. The Doppler probe was coated with sterile water-soluble gel to enhance contact between the probe and the bowel wall and was lightly applied to the intestinal wall at a 45° angle. In each animal, venous flow was occluded for a period of two, four, six, and seven hours in one each of four loops. At the completion of each period of venous occlusion, vascular and intestinal clamps were removed. Ten minutes after venous occlusion was released, the clinical appearance of the intestinal segment was noted, and the Doppler probe was again applied to the antimesenteric surface of the bowel to determine whether arterial flow signals were present.

Following the termination of the longest period of venous occlusion in each animal (seven hours), the abdomen was closed routinely. All animals were reexplored 24 hours later, and the viability of each of the four loops of intestine was assessed.

Results

Doppler arterial signals were easily audible on the antimesenteric surface of each of the twenty loops prior to occlusion of the venous drainage of the segment. Following application of venous occlusion, the bowel and mesentery rapidly became hemorrhagic in appearance. When the segments were checked for arterial Doppler signals ten minutes after application of venous occlusion, no arterial signals could be detected within the intestine, although arterial signals were still clearly audible over the arteries within the mesentery in all 20 segments.

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TABLE 1. *Accuracy of Doppler Ultrasound in Predicting Intestinal Viability*

	Viable	Nonviable
Doppler signals present	9	1
Doppler signals absent	1	9

$p < .01$.

As the period of venous occlusion lengthened, hemorrhagic changes in the bowel became more pronounced and gradually progressed to cyanosis. No improvement could be detected in any of the 20 segments immediately following the release of venous occlusion. None of the segments could be clinically judged unquestionably viable on the basis of color, peristalsis, or presence of palpable mesenteric pulsations.

Following the release of venous occlusion, however, Doppler arterial flow signals were readily detected over the antimesenteric surface of 10 loops, while in the remaining 10 loops of intestine, there was no return of arterial Doppler signals. Of the intestinal loops in which Doppler signals returned, the periods of venous occlusion were two hours in five loops, four hours in four loops, and six hours in one loop. Venous occlusion in segments in which Doppler signals failed to return had lasted seven hours in five loops, six hours in four loops, and four hours in one loop.

At reexploration 24 hours later, nine of the ten segments in which Doppler arterial signals had returned after release of venous occlusion appeared obviously viable (Table 1). The remaining segment was clearly nonviable. Of the 10 segments in which arterial Doppler signals could not be detected after release of venous occlusion nine were obviously infarcted, while one had improved in appearance and was viable. Chi square analysis showed these results to be statistically significant ($p < .01$).

Discussion

This study demonstrated that occlusion of the venous drainage of the bowel produces rapid and dramatic changes in the appearance of the intestine. Edema and hemorrhage within the bowel and mesentery occur rapidly. If venous occlusion remains uncorrected, changes in the intestine progress to cyanosis and then to frank infarction. Clinical assessment of the viability of an involved segment of intestine can be difficult.

In the presence of experimental venous occlusion, Doppler arterial signals within the wall of the intestine quickly disappeared, although they were still detected over the arteries in the mesentery. Following restoration of venous outflow, Doppler arterial signals again became audible in viable intestine. Ninety per cent of the intestinal segments in which arterial signals returned were proved to be viable at re-exploration 24 hours later. Conversely, only one of ten segments in which no return of arterial Doppler signals could be detected was viable 24 hours later. Doppler ultrasound thus proved to be a highly accurate means of predicting intestinal viability, even when the bowel appeared clinically to be severely compromised.

The technique of the use of Doppler ultrasound equipment is relatively simple and easily learned. The Doppler probes can be gas-sterilized for intraoperative use. The tip of the probe is coated with a sterile water-soluble gel to enhance contact between the probe and the bowel wall. The probe is then lightly applied to the wall of the intestine at a 45° angle. Care must be used to avoid excessive pressure on the probe, which may occlude the small vessels within the wall of the intestine. If arterial flow is present, distinct arterial signals are readily detected.

Previous studies have demonstrated the usefulness and accuracy of this technique after interruption of the arterial supply to the intestine. Occlusion of the venous return in intestinal strangulation precedes arterial thrombosis and produces striking changes in the appearance of the intestine. These changes may regress slowly following restoration of venous outflow to the involved segment of intestine. However, arterial flow within the bowel, which can be detected by Doppler ultrasound, resumes quickly. Doppler ultrasound is sufficiently sensitive and accurate to be useful in determining the viability of ischemic intestine resulting from venous obstruction.

References

1. Cooperman M, Martin EW, Jr, Evans WE et al. Assessment of anastomotic blood supply in operations upon the colon by Doppler ultrasound. Surg Gynecol Obstet (in press).
2. Cooperman M, Pace WG, Martin EW, Jr, et al. Determination of viability of ischemic intestine by Doppler ultrasound. Surgery 1978; 83:705.
3. Wright CB, Hobson RW. Prediction of intestinal viability using Doppler ultrasound technics. Am J Surg 1975; 129:642.